GPS OCCULTATION SENSOR (GPSOS)

Sensor Requirements Document (SRD)

for

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS) SPACECRAFT AND SENSORS

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1 SCOPE

1.1 IDENTIFICATION

This Sensor Requirements Document (SRD) sets forth the requirements for a Global Positioning System Occultation Sensor (GPSOS) of the National Polar-orbiting Operational Environmental Satellite System (NPOESS).

1.2 SENSOR OVERVIEW

The GPSOS sensor must satisfy GPSOS requirements for: a) the GPSOS-assigned Environmental Data Records (EDRs), b) the on-orbit determination of position and time, and c) the ground-processed Precise Orbit Determination (POD). The GPSOS sensor makes observations of navigation signals from the Global Navigation Satellite System (GNSS) consisting of the GPS and the GLONASS.

Two types of occultations are possible: rising and setting. A setting occultation starts when the combined orbital motions of the NPOESS satellite and one of the GPS or GLONASS satellites being tracked by the GPSOS sensor are such that the GPS or GLONASS satellite, as viewed from NPOESS satellites, drops below the NPOESS local horizontal plane and ends when the GPS or GLONASS satellite, as viewed from NPOESS, drops behind the Earth's limb. Setting occultations occur for GPS/GLONASS satellites that are in the hemisphere behind the NPOESS satellite (anti-velocity direction). A rising occultation is the inverse of a setting occultation. Rising occultations occur for GPS/GLONASS satellites in the hemisphere in front of the NPOESS satellite. Both setting and rising occultations are to be tracked by **the** GPSOS sensor. Tracking of rising occultations requires that the GPSOS sensor be capable of rapidly locking on the GPS/GLONASS signals as they appear from behind the Earth's limb.

1.3 DOCUMENT OVERVIEW

This document contains all performance requirements for **the** sensor suite. This document also defines all sensor-spacecraft interfaces for the sensor suite. The contractor should use the document as the basis of a proposed sensor suite specification. The documentation listed in section 2.0 follows an approach of minimum specs and standards. The contractor may add to or revise the documents listed in section 2.0 in coordination with the government. The term **"(**TBD**)"** applied to a missing requirement means that the contractor should determine the missing requirement in coordination with the government. The term **"(**TBS**)"** means that the government will supply the missing information in the course of the contract. The term **"(**TBR**)"** means that the requirement is subject to review for appropriateness by the contractor or the government. The government may change **"(**TBR**)"** requirements in the course of the contract.

Appendix A contains a definition of the terms used throughout the document. Appendix B, NPOESS survivability requirements, is classified and, if applicable, will be made available after contract award. Appendix C is a Sensor Data Record Characteristics section presently TBR. Appendix D **references** the **Technical Requirements Document**

Appendix D, which contains the NPOESS EDR requirements. Appendix E contains the RDRs and EDRs required for each Central and Field Terminal (TBR). Appendix F defines the acronyms and abbreviations used throughout the document. Appendix G describes Potential Pre-planned Product Improvements. Appendix H is the Verification Cross Reference Matrix (TBD).

1.3.1 CONFLICTS

SRDX1.3.1-1
In the event of conflict between the referenced documents and the contents of this specification, the contents of this specification shall be the superseding requirements.

SRDX1.3.1-2
In the event of a conflict involving the external interface requirements, or in the event of any other unresolved conflict, the contracting officer shall determine the order of precedence.

1.3.2 REQUIREMENT WEIGHTING FACTORS

The requirements stated in this specification are not of equal importance or weight. The following three paragraphs define the weighting factors incorporated in this specification.

a. ***Shall*** designates the most important weighting level; that is, mandatory. Any deviations from these contractually imposed mandatory requirements require the approval of the contracting officer.
b. ***Should*** designates requirements requested by the government and are not mandatory. Unless required by other contract provisions, noncompliance with the *should* requirements does not require approval of the contracting officer.
d. ***Will*** designates the lowest weighting level. These *will* requirements designate the intent of the government and are often stated as examples of acceptable designs, items, and practices. Unless required by other contract provisions, noncompliance with the *will* requirements does not require approval of the contracting officer and does not require documented technical substantiation.

1.4 SYSTEM CLASSIFICATIONS N/A

2 APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

The following documents, of the exact issue shown, form a part of this SRD to the extent specified herein. SRDX1.3.1-1 provides guidance in the event of a conflict between the documents referenced herein and the contents of this specification. Changes to the document list in this section are (TBR).

SPECIFICATIONS:

Military

DOD-E-83578A May 96	General Specification for Explosive Ordnance for Space Vehicles
Mil-A-83577B Feb 88	Moving Mechanical Assemblies for Space Launch Vehicles

STANDARDS:

Federal

FED-STD-209E Sep 92	Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones

Military

MIL-STD-461D Jan 93	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462D Jan 93	Measurement of Electromagnetic Interference Characteristics
MIL-STD-1540C Sep 94	Test Requirements for Launch, Upper Stage, and Space Vehicles
MIL-STD-1541A Dec 87	Electromagnetic Compatibility Requirements for Space Systems
MIL-STD-1553B Jan 96	Digital Time Division Command/Response Multiplex Data Bus
MIL-STD-1773B May 88	Fiber Optics Mechanization of an Aircraft Internal Time Division Command/Response Multiplex Data Bus

Department of Commerce/NOAA: None (TBR)

OTHER PUBLICATIONS:

Regulations

AFM 91-201 7 Oct 94	Explosive Safety Standards
EWR 127-1 31 Mar 95	Eastern and Western Range Safety Requirements

Handbooks None (TBR)

Bulletins None (TBR)

Other

GPS ICD 200 REV C, 19 January 1995	"NAVSTAR GPS Space Segment/Navigation User Interface"(U) UNCLASSIFIED

(Contractors requiring copies of specifications, standards, handbooks, drawings, and publications in connection with specified acquisition functions should obtain them from the contracting activity or as directed by the contracting officer.)

2.2 NONGOVERNMENT DOCUMENTS

The following documents, of the exact issue shown, form a part of this SRD to the extent specified herein. SRDX1.3.1-1 provides guidance in the event of a conflict between the documents referenced herein and the contents of this specification. Changes to the document list in this section are (TBR).

SPECIFICATIONS: None (TBR)

STANDARDS:

CCSDS 203.0-B-1 Jan 87	CCSDS Recommendations for Space Data System Standards. Telecommand, Part 3: Data Management Service, Architectural Definition, Issue 1
CCSDS 701.0-B-2 Dec 87	CCSDS Recommendations for Advanced Orbiting Systems, Networks and Data Links, Architectural Specification
National Aerospace Standard (NAS) 411 Rev 2, 29 Apr 94	Hazardous Materials Management Program

DRAWINGS: None (TBR)

OTHER PUBLICATIONS: None (TBR)

2.3 REFERENCE DOCUMENTS

The following documents are for reference only and do not form a part of this specification.

SPECIFICATIONS:

Military None (TBR)

STANDARDS:

DOD 5200.28-STD Mar 88	Department of Defense Trusted Computer System Evaluation Criteria
MIL-STD-129M 1 Jun 93	Marking for Shipment and Storage Notice 1, 15 Sep 89
MIL-STD 961D Aug 95	DoD Standard Practice for Defense Specifications, w/ Notice 1
MIL-STD-498 5 Dec 94	Software Development and Documentation
MIL-STD-882c Jan 93	System Safety Program Requirements
MIL-STD-1246C Apr 94	Military Standard Product Cleanliness Levels and Contamination Control Program
MIL-STD-1522A May 84	Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems
MIL-STD-1542B Nov 91	Electromagnetic Compatibility (EMC) and Grounding Requirements for Space Systems Facilities
MIL-STD-1543B Oct 88	Reliability Program Requirements for Space and Launch Vehicles
MIL-STD-1547A Dec 92	Parts and Materials Program for Space and Launch Vehicles
MIL-STD-1809 Feb 91	(USAF) Space Environments for USAF Space Vehicles

TM-86-01	Technical Manual Contract Requirements

Department of Commerce

DOC Sep 95 Edition Sep 95	National Telecommunications and Information Administration, Manual of Regulations for Federal Radio Frequency Management

NOAA

S24.801 2 Dec 88	Preparation of Operations and Maintenance Manuals
S24.806 30 Apr 87	Software Development, Maintenance, and User Documentation
S24.809 Dec 89	Grounding Standards

NASA

PPL-21 March 1995	Preferred Parts List, Goddard Space Flight Center (Updated May 1996)
SP-R-0 022A (JSC) 9 Sep 74	General Specification, Vacuum Stability Requirements of Polymeric Material for Spacecraft Application
NASA Tech Memo 100471	Orbital Debris Environments for Spacecraft Designed to Operate in Low Earth Orbit
SP 8031 1969	NASA Space Vehicle Design Criteria/Structures

OTHER PUBLICATIONS:

Regulations None (TBR)

Handbooks

DOD-HDBK-263B (date)	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, Equipment
MIL-HDBK-340 1 Jul 85	Application Guidelines for MIL-STD-1540B
DOD-W-83575 Jun 96	Gen Spec for Wiring Harness, Space Vehicle, Design and Testing
MIL-I-46058	Insulating Compound, Electrical (for Coating Printed Circuit Assemblies)

1985	Handbook of Geophysics and Space Environments
AFM 15-111 1 Sep 96	Surface Weather Observations

Bulletins

Other

TRD for NPOESS (current version)	Technical Requirements Document (TRD) for National Polar- Orbiting Operational Environmental Satellite System (NPOESS) Spacecraft Payloads
IRD for NPOESS (current version)	Interface Requirements Document (IRD) for National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Spacecraft
IORD for NPOESS 28 Mar 96	Integrated Operational Requirements Document (IORD) for National Polar Orbiting Operational Environmental Satellite System (NPOESS) Spacecraft Payloads
ASTME-595-93 (current version)	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials for Outgassing in a Vacuum Environment
Attachment C S- 480-80 Revised December 1994	AMSU-A Instrument Performance and Operation Specification (for the EOS/METSAT Integrated Programs); NASA GSFC
SYS/AMS/J0105/ BAE 03 Feb 1993	AMSU-B Instrument System Specification (British Aerospace)

(Technical society and technical association specifications and standards are generally available from reference libraries. They are also available in technical groups and using federal agencies. Contact the contracting officer regarding any referenced document not readily available from other sources.)

3 SENSOR REQUIREMENTS

3.1 DEFINITION

3.1.1 SENSOR DESCRIPTION

The GPSOS sensor is one of several sensors under development by the Integrated Program Office (IPO) for utilization by POES/DMSP and NPOESS era satellite constellations. The GPSOS sensor provides real-time, on-orbit positioning, timing, and acquires data to enable ground processing yielding precise orbit determination (POD), and occultation event phase/amplitude data to within the specifications listed below. The offeror's proposal addresses each of the areas and provides rationale and supporting analysis for all deviations. The Government desires to provide early NPOESS data to users by possibly flying one or more of the GPSOS sensors on POES and DMSP. This Sensor Requirement Document (SRD) for GPSOS defines the NPOESS GPSOS sensor requirements. The NPOESS era constellation is planned to contain 3 satellites: 2 US built and 1 built by EUMETSAT.

There will be approximately 5200 occultation events daily experienced by the NPOESS constellation using the GPS and GLONASS satellite signals. The GPSOS sensor measured occultation data will support determination of atmospheric vertical profiles of: a) ionospheric electron density, and b) provide tropospheric temperature, pressure, and moisture content (when merged with other ground-based data sensor data).

3.1.1.1 General Sensor Characteristics

The **separate** GPSOS **components** interface with the host satellite (DMSP/POES/METOP and NPOESS). There are several nadir viewing sensors on-board the satellite and the GPSOS sensors and antennas cannot interfere with DMSP/POES/METOP or NPOESS missions.

There are additional concerns regarding potential multipath effects on the GPS/GLONASS signals attributable to the host satellite structure. The GPSOS antenna(s) design minimizes these multipath effects. Assuming a 0 dB antenna gain with GPS/GLONASS signals, the GPSOS receiver sensitivity requirement is estimated to be -130 dBm for Right Hand Circular Polarization (RHCP).

SRDG3.1.1.1-1
Spurious multipath signals of Left Hand Circular Polarization (LHCP) shall be rejected by an additional 20 dB.

SRDG3.1.1.1-2
The GPSOS sensor developer shall work with the spacecraft contractor to determine the exact location(s) for the antenna(s).

SRDG3.1.1.1-3
The GPSOS sensor provides sensor status or housekeeping data to the spacecraft for use in the downlink. The GPSOS sensor shall have the capability to internally measure power supply voltages and temperatures to 1% accuracy.

SRDG3.1.1.1-4
For test and pre-flight sensor checkout, an auxiliary RS-422 serial port shall support direct communication with the GPSOS sensor and mechanism to retrieve mission data and sensor housekeeping data. Over this port, a technician has control of the sensor using a laptop and is able to receive mission data, command responses, and housekeeping data. See Table 3.1.1.1, Footnote (d).

SRDG3.1.1.1-5
The GPSOS sensor quality shall be sufficient to satisfy requirements for the determination of position, per SRDG3.2.1.1-1.

SRDG3.1.1.1-6
The GPSOS sensor quality shall be sufficient to satisfy requirements for the determination of time, per SRDG3.2.1.1-2.

SRDG3.1.1.1-7
The GPSOS sensor shall be able to operate automatically with "power on," but also be able to be reconfigured by simple ground commands, e.g., redundancy commands, changes in sampling frequencies, etc.

SRDG3.1.1.1-8
Receiver data quality shall be sufficient to support troposphere/stratospheric occultation measurement analysis. The latter involves ground-based precise orbit determination using GPSOS data combined with non-NPOESS ground data (e.g., IGS) to determine the position and velocity of the NPOESS and GPS/GLONASS satellites. EDR values will be updated within 20 minutes of receipt of the data at the Central or Tactical site. The Navigation/POD and Troposphere/Stratosphere columns in Table 3.1.1.1 provide the requirements levied on the receiver associated with this analysis.

SRDG3.1.1.1-9
The GPSOS sensor contractor shall be responsible for definition of the ground-based processing algorithm yielding NPOESS velocity uncertainty to less than 0.5 mm/sec and position uncertainty to less than 0.5 m.

SRDG3.1.1.1-10
Nominal channels: 5-6 channels each, for navigation both GPS and GLONASS; 8 channels for GPS occultations, and 8 channels for GLONASS occultations. A single channel shall be defined as all observables associated with a single satellite at both L1 and L2 frequencies (GPS) or both L1 and L2 frequency bands (GLONASS). Note: Within the next 5-7 years, the GPS Block II F satellites may have an additional frequency, i.e., L5 at approximately 1140 MHz. The GPSOS sensor will utilize L5 capability to improve the delineation of the ionosphere refraction and navigational precision as a GPSOS sensor Preplanned Product Improvement (P3I) capability, when available.

SRDG3.1.1.1-11
The GPSOS sensor shall support single difference occultation processing. This requires a very low short-term clock drift specification (<10 mm in 50 seconds) and low phase noise close to the carrier (<0.10 degrees of phase uncertainty).

SRDG3.1.1.1-12
The GPSOS shall provide four configurable sample rates (see Table 3.1.1.1) within each altitude range: a) Troposphere from 0 km to 20 km - configurable sample rate between 10-100 Hz; b) Middle atmosphere/E-region above 20 km to 150 km - configurable sample rate between 5-20 Hz; c) Ionosphere >150 km - sample rate configurable within the range of 0.5 to 5.0 Hz, (e.g., 0.5, 1.0, 2.0, **&** 5.0 Hz); and d) NAV data - configurable sampling rate range 1-300 seconds (e.g., 1,5,10,30,60, & 300 seconds).

SRDG3.1.1.1-13
The GPSOS shall be capable of removing the effects of Selective Availability meeting all specifications when Y-code is enabled.

SRDG3.1.1.1-14
On a daily basis, > 98% **(TBR)** of the available occultation events (rising and setting for GPS and GLONASS) shall be measured, i.e., 98% **(TBR)** of the available occultation events within plus or minus 180 **(TBR)** degrees of the satellite's velocity vector.

SRDG3.1.1.1-15
The GPSOS shall have the ability to perform: on-orbit inter-frequency bias calibrations, calibrate hardware induced absolute channel delays on each channel, and calibrate the interchannel bias for both GPS and GLONASS.

SRDG3.1.1.1-16
GPSOS sensor software shall be 100% fully reprogrammable by command to the satellite from the ground. The boot strap loader resides in ROM.

SRDG3.1.1.1-17
The GPSOS sensor memory shall be twice what is required to support the mission on Day #1.

SRDG3.1.1.1-18
GPSOS sensor shall be able to maintain track on occulted satellites (GPS and GLONASS) to within 5 km above the Earth's limb (setting occultations) and acquire track within 10 km (rising occultations) above the Earth's limb with a > 90% probability.

SRDG3.1.1.1-19
The GPSOS shall use the GPS and GLONASS to perform its navigation function and to produce its assigned set of Primary and Secondary EDRs.

SRDG3.1.1.1-20
Deleted.

SRDG3.1.1.1-21
These specifications (Table 3.1.1.1) shall be analyzed (Physical Optics - PO, Geometric Theory of Diffraction - GTD, or Method of Moments - MOM, as appropriate) and verified using compact range measurements on full**-** or sub-scale model**s**, as appropriate.

SRDG3.1.1.1-22
These analyses and corresponding compact range performance verification measurements shall serve as the basis for factory acceptance testing of the GPSOS sensor.

Table 3.1.1.1 GPSOS Sensor Characteristics

Receiver Parameter	RT Navigation [d]	Navigation/POD	Ionosphere	Troposphere/Stratosphere
1. Configurable Sample Rate	0.10 Hz	0.10 Hz	1 Hz	100 Hz
2. Carrier Phase Precision @ Sample Rate [b]	3.0 mm	3.0 mm	3.0 mm	0.1 mm (L1 @ 1 sec) 0.4 mm (L2 @ 1 sec) [c]
3. Systematic Carrier Phase Drift/Accuracy	1.0 mm/sec	0.1 mm/sec	0.1 mm/sec	0.1 mm/sec
4. Carrier Amplitude Stability (% change over 60 seconds) [a]	N/A	N/A	< 1.0	< 1.0
5. Carrier Amplitude RMS Jitter (% @ 20 msec)	N/A	N/A	< 2.0	< 2.0
6. Pseudorange Position (m)	0.25 m P-code 15.0 m C/A-code	0.3 m (dual frequency, 10 sec)	0.3 m threshold L1-L2 differential	N/A
7. Pseudorange Systematic Errors (m)	TBS	0.01	N/A	N/A
8. Scintillation Parameters	N/A	N/A	Every 10 sec derived from underlying high rate amplitude & phase	N/A
8. Amplitude Precision	8 bits	10 bits	12 bits	12 bits

Footnotes:

a) Amplitude Stability - during a troposphere/stratosphere occultation event, i.e., 60 seconds, the system noise and gain stable to 1.0%

b) Phase cycle slips should be minimized with no more that a 99.9% probability within one orbit period at a receive sensitivity of -130 dBm.

c) A GPSOS sensor with an antenna gain > 0 dBi might contribute.

d) RT Navigation - real time, on-orbit navigation data and master clock data made available to the satellite computer.

3.1.2 SYSTEM SEGMENTS N/A

3.1.3 SPECIFICATION TREE

Figure 3.1.3 shows a partial specification tree for the NPOESS System.

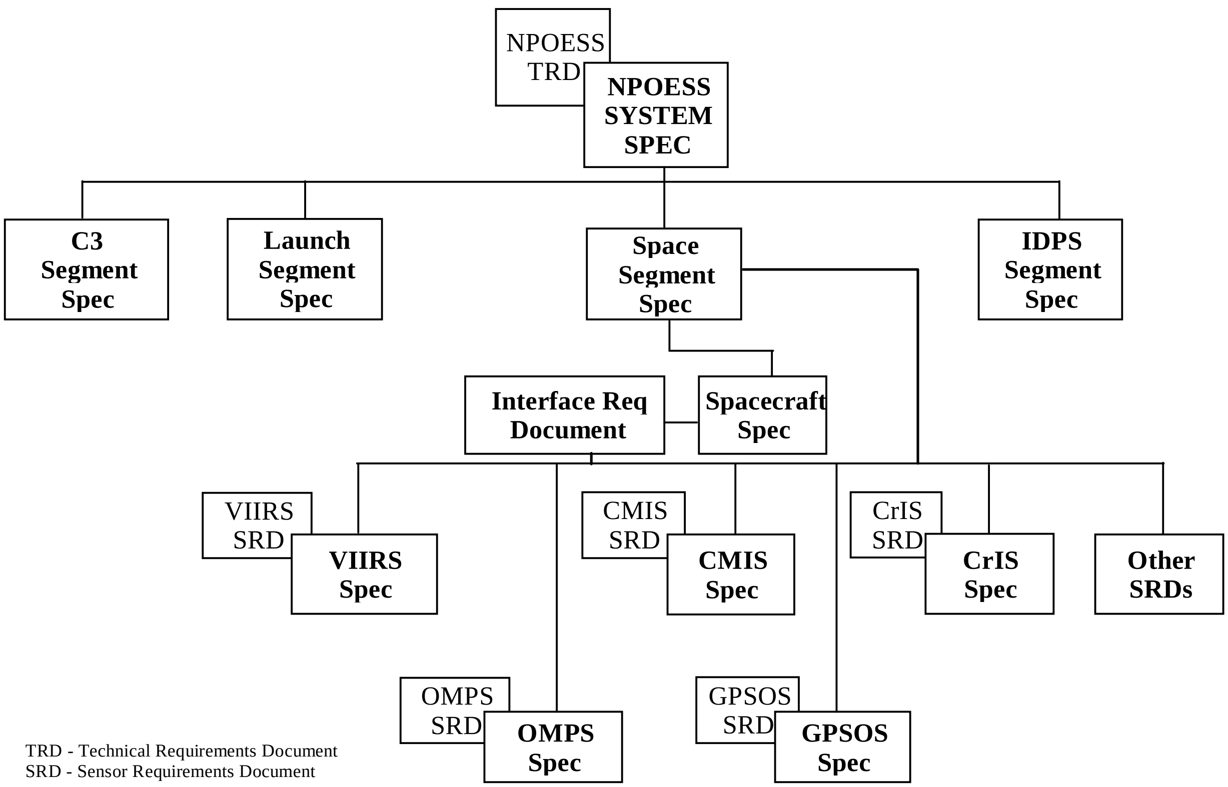

Figure 3.1.3 Partial Specification Tree

3.1.4 TOP-LEVEL SENSOR FUNCTIONS

See Section 3.1.6.2.

3.1.5 SENSOR MODES

3.1.5.1 Common Sensor Modes

3.1.5.1.1 Sensor Off Mode

SRDG3.1.5.1.1-1
In the sensor off mode, no power shall be supplied to the sensor.

3.1.5.1.2 Operational Mode

The sensor maintains operational modes as follows:

SRDG3.1.5.1.2-1
The sensor shall be in full functional configuration during this mode.

SRDG3.1.5.1.2-2
Data collection - Mission and housekeeping data shall be collected.

SRDG3.1.5.1.2-3
Calibration - Calibrations shall be done during regular operations.

3.1.5.1.3 Sensor Diagnostic Mode

SRDG3.1.5.1.3-1
Diagnostic mode shall include trouble shooting and software updates.

3.1.5.1.4 Sensor Safe Hold Mode

In the Safe Hold mode, health and status data are collected and transmitted. Mission and calibration data are not collected. Safe State - Most Components turned off, with survival heaters activated.

SRDG3.1.5.1.4-1
The Safe Hold Mode is a power conservation mode. The GPSOS sensor shall be commanded into this mode automatically by the spacecraft in the event the satellite enters an anomalous configuration or orientation as determined by the satellite computer. A power subsystem anomaly is such an event.
The C&DH will issue power conservation re-configuration commands to the sensors via the data bus that will place the sensor in a safe configuration. The return to the Operational Mode requires ground intervention.

3.1.5.2 GPSOS Sensor Specific Modes

SRDG3.1.5.2-1
The GPSOS shall provide determinations of position and time, per SRDG3.2.1.1-1 and SRDG3.2.1.1-2, in the sensor Operational Mode.

3.1.5.3 Payload Mode Documentation

SRDG3.1.5.3-1
The sensor ICD shall define Payload (Sensor) modes.

SRDG3.1.5.3-2
The ICD SAFE shall define Mode re-configuration commands.

3.1.6 OPERATIONAL AND ORGANIZATIONAL CONCEPT

3.1.6.1 Launch Operations Concept

3.1.6.1.1 Pre-launch

The satellite will be transported directly to the launch base for final vehicle preparations and checkout. Final inter-segment and launch system verification tests will be accomplished prior to launch.

The GPSOS sensors will be delivered and integrated onto the specified satellite platforms.

SRDG3.1.6.1.1-1
During integration, various GPSOS verification tests are required. The GPSOS sensor shall provide data interface and sensor diagnostics as described in Section 3.1.1.1. The satellite will be transported directly to the launch base where final vehicle preparations and checkout will be accomplished. Final inter-segment and launch system verification tests will be accomplished prior to launch.

3.1.6.1.2 Launch

The GPSOS sensor will be turned on as soon as is practical to assist in the satellite early orbit tracking and provide ephemeris data.

SRDG3.1.6.1.2-1
During launch and injection to the operational orbit, the GPSOS sensor shall be powered on unless recommended otherwise by the vendor in order to provide protection from the launch and injection environments. Specifically, the GPSOS sensor can support early anomaly resolution by providing navigational data to the satellite and is useful for monitoring satellite vehicle status.

SRDG3.1.6.1.2-2
Satellite telemetry, which includes GPSOS navigational data, shall be transmitted to ground monitoring stations to be used to the extent practicable during the injection phase.

SRDG3.1.6.1.2-3
After insertion into its operational orbit and separation from the launch vehicle, appropriate deployments shall be initiated by memory command. Early orbit check-out will be conducted at the NPOESS primary SOC in Suitland, MD.

3.1.6.2 On-orbit Operational Concept

3.1.6.2.1 Overview

The NPOESS satellite will operate in a near circular, sun-synchronous orbit. The nominal orbit for the satellite is 833 km altitude, 98.7 (TBR) degree inclination. The orbit will be a "precise" orbit (i.e., altitude maintained to ± TBS km, nodal crossing times maintained to ± 10 minutes throughout the mission lifetime) to minimize orbital drift (precession). NPOESS must be capable of flying at any equatorial node crossing time. However, the nominal configuration is with the satellite orbits equally spaced, with 0530 and 1330 nodal crossing times for the U.S. Government satellites and 2130 for the METOP satellite.

The sun Beta angle, β, is the angle between the solar vector (i.e., the satellite-sun line) and the orbit plane. For sensor thermal design purposes, the range of β for the NPOESS missions is ± 90 degrees. The satellite will maintain the sun on the appropriate side of the satellite to meet the 'all beta' requirement. Sensor suite design allows for approximately a 5 degree infringement of sun on the cold space side of the satellite in the case of a noon or midnight orbit.

The GPSOS is also a sensor with early flight opportunity potential on DMSP and POES. The above information describing NPOESS satellite orbital parameters is intended as guidance to the Contractor.

3.1.6.2.2 On-orbit Tests

The initial on-orbit period is devoted to a complete satellite checkout and the calibration and performance verifications of the payload(s). The satellite and payload performance verification tests may be repeated at appropriate times during the operational phase of the mission.

3.1.6.2.3 Operations

SRDG3.1.6.2.3-1
The GPSOS sensor shall be capable of operating for 21 days with a goal up to 60 days without additional commands.

SRDG3.1.6.2.3-2
On-orbit storage of occulting and non-occulting satellite data for transmission to the satellite C3 subsystem shall be at variable rates dependent on the altitude of the GPS/GLONASS signal path above the Earth's surface (the "ray tangent altitude"). The GPSOS sensor sample rates are selectable by ground control commands selectable in each band between the defined limits in four atmospheric regimes/vertical profiles: a) troposphere – surface to 20 km @ 10-100 Hz; b) stratosphere to E region ionosphere – 20 km to 150 km @ 5-20 Hz; **c)** ionosphere **–** 150 km to 1000 km @ 0.5 to 5.0 Hz; and **d)** navigation @ 1.0 - 0.03 Hz.. Data from these different regions is used in different ways during ground processing to produce different products as described below.

SRDG3.1.6.2.3-3
Deleted.

SRDG3.1.6.2.3-4
With the exception of the scintillation parameters, processing of the GPSOS data into Environmental Data Records (EDRs) is performed on the ground. Two classes of EDRs are derived from the GPSOS data: tropospheric/stratospheric and ionospheric. Both classes of EDR shall be produced in near real-time (i.e., within 20 minutes of receipt of the data at the Central or Tactical site). The GPSOS sensor contractor is responsible for producing EDRs from the GPSOS sensor RDRs.

Calculation of tropospheric/stratospheric EDRs (i.e., atmospheric temperature and water vapor profiles) involves determination of the atmospheric contribution to the observed GPS/GLONASS signal Doppler. However, prior to this determination, the observed signals are corrected for any clock errors associated with the GPSOS reference oscillator or the GPS/GLONASS satellite clocks. Clock errors within GPSOS are removed by use of a reference satellite.

SRDG3.1.6.2.3-5
When observing an occultation, the GPSOS shall simultaneously select and track a non-occulted reference satellite at the same higher rate as the occulted satellite.

This allows the use of the single-differencing data processing technique to correct GPSOS clock errors during ground processing. Clock errors in the GPS/GLONASS satellites are of one of two types: slow drift in the on-board atomic clocks (present for both GPS and GLONASS) and the intentionally induced errors associated with selective availability (GPS only). Apart from the effects of Selective Availability (S/A), the GPS and GLONASS satellite clocks are believed to be stable enough to allow accurate determination of EDRs without any corrections. With regard to the errors induced by S/A, other occultation sensors, i.e., GPS/MET has used data from ground-based GPS receivers in a double-differencing scheme to make the needed corrections.

Given the observations after correction for clock errors, the atmospherically induced Doppler is determined by subtracting the Doppler due to relative GPS/GLONASS-NPOESS satellite motion from the observed Doppler. Determining the Doppler due to satellite motions in turn requires high precision orbit determination for both GPS/GLONASS satellites and for NPOESS. High accuracy GPS and GLONASS ephemerides are obtained on the ground through processing of data from ground-based (non-NPOESS) GPS and GLONASS receivers, i.e., the IGS system. The high accuracy GPS/GLONASS ephemerides are then used together with GPSOS observations of non-occulted satellites to determine **the** high accuracy ephemeris for NPOESS.

SRDG3.1.6.2.3-6
In order for the precise ephemeris to be determined, the position of the GPSOS antenna(s) phase center(s) relative to the satellite center-of-mass shall be accurately known to < 1.0 cm.

In addition, an accurate map of antenna amplitude and phase as a function of look angle are known. With the high accuracy ephemerides of all satellites known, it is then possible to remove the orbital motion induced contribution to the signal Doppler and determine the atmospheric contribution. The atmospherically induced Doppler is related to the amount of bending of the ray path between NPOESS and the occulted satellite. The bending, after a dual frequency correction for the effects of the ionosphere along the ray path, is in turn related to the atmospheric refractivity profile. This profile will be obtained by applying the appropriate data inversion scientific algorithms. The refractivity profiles may be converted into atmospheric temperature and water vapor profiles.

Determination of electron density profiles and slant path **Total Electron Content (**TEC**)** from GPSOS data should involve one of two techniques, or some combination thereof. A single frequency method based on ray path bending is possible which involves considerations similar to those described above for the troposphere/stratosphere (correction of clock errors and subtraction of geometric Doppler). Alternately, a dual

frequency scientific algorithm exists whereby line-of-sight TEC observations obtained from the differential pseudorange and phase are converted into a vertical electron density profile. Occultations which occur off to the side of the NPOESS satellite (out-of-track occultations) provide useful information for NPOESS end users, but can not be processed into vertical electron density profiles due to the substantial change in tangent point location during the occultation. Slant path TEC observations from these types of occultations should be produced as part of the GPSOS ground processing. Accurate measurement of TEC requires knowledge of the inter-frequency bias of both the GPSOS receiver and the transmitters on the GPS and GLONASS satellites.

SRDG3.1.6.2.3-7
In addition to vertical electron density profiles, the GPSOS data shall also be used to produce observations of the total electron content (TEC) above the NPOESS satellite. Data from non-occulted satellites is used for this purpose.

SRDG3.1.6.2.3-8
The GPSOS shall be capable of providing sensor data of sufficient accuracy to support the ground-processed Precise Orbit Determination (POD), per SRDG3.1.1.1-9.

3.1.6.2.4 GPSOS Sensor Checkout and Diagnostics

SRDG3.1.6.2.4-1
The GPSOS sensor shall be equipped with an RS422 serial port that permits direct access to the GPSOS sensor housekeeping, power supply status-temperature and voltage, and communications link. This port permits full access and control of the GPSOS sensor using a laptop in order to receive data, command responses, and verify/measure sensor status and subsystem interfaces.

SRDG3.1.6.2.4-2
During flight operations the mission controllers shall be able to monitor the GPSOS sensor status and functions. For all diagnostic GPSOS sensor parameters are identified as well as specification of parameter range tolerances, sensor anomalies, fault diagnostics, and failure modes. The GPSOS sensor operates with “power on,” but also be reconfigurable by simple ground commands, e.g., redundancy commands, changes in sampling frequencies, etc.

3.1.6.2.5 GPSOS Contractor Responsibilities

The GPSOS sensor contractor is responsible for the following elements of the GPSOS system:

SRDG3.1.6.2.5-1
The GPSOS sensor contractor shall be responsible for the GPSOS spaceflight hardware and software.

SRDG3.1.6.2.5-2
The GPSOS sensor contractor shall be responsible for the calibration of the GPSOS receiver and antenna(s).

SRDG3.1.6.2.5-3
The GPSOS sensor contractor shall be responsible for ground-based performance verification of sensor performance and acceptable multipath levels as verified by compact range test on a full scale satellite (mock up) and GPSOS sensor.

SRDG3.1.6.2.5-4
The GPSOS sensor contractor shall be responsible for development of scientific algorithms that will be used for ground processing in the IDPS. When applied, the algorithms should be capable of providing ionospheric EDRs. RDRs shall be of sufficient accuracy and precision to allow processing of tropospheric/stratospheric EDRs (temperature or humidity) meeting the clear air accuracy defined for the CrIMSS sensor.

SRDG3.1.6.2.5-5
The GPSOS sensor contractor shall be responsible for ground processing software for refining the GPSOS navigation data accuracy to the level required to support NPOESS imagery geolocation.

SRDG3.1.6.2.5-6
The GPSOS sensor contractor shall be responsible for the following elements of the GPSOS system:

1) Ground processing software and auxiliary ground data sources needed to convert SDRs into ionospheric, troposphere, and stratospheric EDRs.
2) Each GPSOS sensor identifies itself with a unique serial number and ROM code version number every time it boots.

3.1.7 MISSIONS

Deleted.

3.2 SENSOR CHARACTERISTICS

3.2.1 PERFORMANCE CHARACTERISTICS

3.2.1.1 Performance Requirements

SDRG3.2.1.1-1
The GPSOS shall provide, once per second, an on-orbit determination of sensor position within the World Geodetic System (WGS-84) with an rms uncertainty of 25/25/25 meters for the radial/in-track/cross-track components, respectively, and referenced to the GPSOS Time (GT), per SRDG3.2.1.1-2.

SRDG3.2.1.1-2
The GPSOS shall provide, once per second, an on-orbit determination of GPSOS Time (GT) within the Universal Time Coordinated (UTC) reference having an absolute correlation of time of 1 microsecond or better. UTC(USNO), kept by the U.S. Naval Observatory, is the standard time reference. As an objective, the GPSOS should provide a time reference capable of an absolute correlation of time to 100 nanoseconds.

3.2.1.1.1 GPSOS Environmental Primary Vs Secondary EDRs

Definitions of “primary” and “secondary” EDRs appear in the glossary and are replicated below.

The GPSOS SRD levies on the GPSOS contractor only those EDR attributes for which the sensor has primary EDR scientific algorithm responsibility (primary EDR). Requirements for the sensor to provide data as a secondary input to an EDR scientific algorithm assigned to another sensor (secondary EDR) are (TBR) and will be established 60 days prior to SRR. Though not yet specified as requirements, the secondary EDRs are listed in the SRD to encourage investigation of secondary EDR capabilities in the GPSOS sensor design. Note also that the GPSOS sensor contractor identifies specifications for any data required from other sources in order to meet the attribute requirements of the primary EDR assigned to the GPSOS sensor.

3.2.1.1.1.1 Definition - Primary EDR

EDR attributes for which a sensor contractor has been assigned primary sensor and scientific algorithm development responsibility. The scientific algorithm may or may not require the use of additional data from other than the primary sensor.

3.2.1.1.1.2 Definition - Secondary EDR

EDR attributes for which a sensor may provide data as a secondary input to an EDR scientific algorithm assigned as a primary EDR to another sensor contractor.

3.2.1.1.2 EDR Requirements

SRDG3.2.1.1.2-1
The environmental data records (EDRs) shall meet the requirements specified in this GPSOS SRD.

SRDG3.2.1.1.2-2
The primary EDRs shall meet the threshold levels as a minimum.

SRDG3.2.1.1.2-3
The modifications and clarifications of EDR requirements in this section shall take precedence over any conflicting requirements or statements in Appendix D of the TRD, and the IORD.

3.2.1.1.2.1 Requirements Format

EDR requirements are specified by a general definition of the required data content, the units for the reported data, and a set of attributes. These attributes fall into four categories: (1) those that further define data content in a precise, quantitative manner, (2) those that constrain the quality of the data to be provided, (3) those that constrain the reporting frequency for the EDR, and (4) the timeliness of EDR delivery to users. The attributes addressing data content are horizontal and vertical cell size, horizontal and vertical reporting interval, and horizontal and vertical coverage. The attributes addressing data quality are measurement uncertainty, measurement accuracy, measurement precision, long term stability, and mapping uncertainty. The primary attributes addressing reporting frequency are maximum local average revisit time and maximum local refresh. All of these attributes apply to data products, not to sensor performance characteristics, and are defined in the Glossary. The EDR requirements format is to address the data content attributes first, then the data quality attributes, and finally the reporting frequency attributes. The timeliness requirement is the same for all EDRs, and is specified as a global requirement. General EDR requirements fall into two classes: (a) explicit requirements on the EDR content, quality, refresh, and timeliness, and (b) requirements to be derived by the contractor based on requirements for other EDRs. The explicit and application-related requirements are specified below.

SDRG3.2.1.1.2.1-1
If a derived requirement conflicts with an explicit requirement and/or another derived requirement, the most stringent requirement shall be satisfied.

3.2.1.1.2.2 Attribute Values

SDRG3.2.1.1.2.2-1
Unless otherwise specified, attribute values shall be interpreted as upper bounds anywhere in the area where measurements are obtained, including the edge of the measuring sensor field of regard. A threshold or objective is "met" or "satisfied" if the system performance value is less than or equal to the specified value.

3.2.1.1.2.3 Attribute Values Expressed as Percentages

Unless otherwise specified, a percentage appearing as a value for an attribute is to be interpreted as the percentage of the true value of the attribute. For any attribute where a percentage and a numerical value are specified, the greater of the two is the requirement.

3.2.1.1.2.4 Vertical Height

Vertical height is measured either by atmospheric pressure or by height above the Earth's surface. A value of zero km for height refers to the Earth's surface. Negative values of height refer to depth below the Earth's surface (land or water).

3.2.1.1.3 GPSOS EDRs

The attribute numbering is consistent with Appendix D **of the TRD,** except for the preface letter which indicates it is a unique requirement in this GPSOS SRD. Any difference in these GPSOS SRD attributes take precedence over Appendix D values as they reflect an intentional requirements allocation to this sensor.

3.2.1.1.3.1 Primary GPSOS EDRs

3.2.1.1.3.1.1 Electron Density Profiles/Ionospheric Specification

The ionosphere is that portion of the Earth's upper atmosphere which is composed of electrically charged particles (electrons and various ions). A complete vertical electron density profile would extend from the D and E regions at altitudes between 60 and 150 km, through the F region within which the electron density reaches a maximum value nominally between altitudes of 250-350 km, through the topside up to 3,000 km, and into the plasmasphere. The Air Force requires global ionospheric specification to meet a number of operational needs. Electron density profile measurements, to include measurements of various important parameters associated with a complete profile, are required as inputs to and to augment the outputs of operational ionospheric models. The GPSOS sensor data will be used to produce slant path (NPOESS to GPS/GLONASS satellite) total electron content (TEC) measurements for all occultation events. In addition, for occultation events which occur in viewing directions close to the spacecraft orbit plane (within TBR degrees of the velocity or anti-velocity vectors), the GPSOS sensor data will be used to produce vertical electron density profiles for altitudes below the NPOESS altitude. Profile measurements above the NPOESS altitude are not required. However, the GPSOS sensor data from non-occulting satellites will be used to produce slant path TEC observations of the topside/plasmasphere.

Units:
Electron density: cm^{-3}
HmF2: km
TEC: $10^{16}/m^2$ = 1 TEC unit

Para. No.		Thresholds	Objectives
G40.8.5-1	a. Horizontal Reporting Interval	(TBD) based on > 98% of all possible occultation events	100%
G40.8.5-2	b. Vertical Reporting Interval (Applicable to profile only)	10 km within 100 km of E/F peaks, 20 km elsewhere	5 km
	c. Horizontal Cell Size		
G40.8.5-3	1. 0-30° latitude	(TBD)	100 km
G40.8.5-4	2. 30-50° latitude	(TBD)	250 km
G40.8.5-5	3. 50-90° latitude	(TBD)	50 km
G40.8.5-6	d. Vertical Cell Size (Applicable to profile only)	10 km within 100 km of E/F peaks, 20 km elsewhere	5 km
G40.8.5-7	e. Horizontal Coverage	(TBD) based on > 98% of all possible occultation events	(TBD)
G40.8.5-8	f. Vertical Coverage	(TBD)	(TBD)
	g. Measurement Range		
G40.8.5-9	1. Density profile	$3x10^5$-10^7 cm^{-3}	10^4-10^7 cm^{-3}
G40.8.5-10	2. Slant path TEC	3-1000 TEC units (TBR)	1-1000 TEC units
	h. Measurement Uncertainty		
G40.8.5-11	1. Density profile	Greater of 20% or $3x10^5$ cm^{-3} (TBR)	10^4 cm^{-3}
G40.8.5-12	2. HmF2	20 km	5 km
G40.8.5-13	3. HmE	(TBD)	(TBD)
G40.8.5-14	4. Slant path TEC	3 TEC units	1 TEC unit
G40.8.5-15	i. Maximum Local Average Revisit Time	(TBD)	(TBD)

3.2.1.1.3.1.2 Ionospheric Scintillation

Temporal and spatial fluctuations in ionospheric electron density lead to fading or disruption of trans-ionospheric communication and radar signals, a phenomenon known as scintillation. The extent of the effect depends on the relative motion of the ionosphere and the signal source, the frequency of transmission, and the amplitude and spectral characteristics of the ionospheric fluctuations. Direct measurements of scintillation in terms of amplitude and phase fluctuation indices S_4 and sigma-ø are required. Spectral analysis of amplitude and phase measurements is desirable as well.

Units:
S_4: Dimensionless
sigma-ø: radians

Para. No.		Thresholds	Objectives
G40.8.11-1	a. Horizontal Cell Size	(TBD)	50 km
G40.8.11-2	b. Horizontal Coverage	(TBD)	(TBD)
	c. Measurement Range		
G40.8.11-3	1. S_4	0.1-1.5	(TBD)
G40.8.11-4	2. sigma-ø	0.1-20 radians	(TBD)
	d. Measurement Uncertainty		
G40.8.11-5	1. S_4	0.1	(TBD)
G40.8.11-6	2. sigma-ø	0.1 radian	(TBD)
G40.8.11-7	e. Local Time Range	(TBD)	(TBD)

3.2.1.1.3.2 Secondary GPSOS EDRs

GPSOS secondary EDR requirements are EDR attributes for which a sensor may provide data as a secondary input to an EDR scientific algorithm assigned as a primary EDR to another sensor contractor. These EDRs are regarded as secondary because the scientific algorithms and the inter-relationship to other NPOESS sensors are TBS items. Following is a listing of secondary EDRs for the GPSOS:

A. Atmospheric Vertical Moisture Profile
B. Atmospheric Vertical Temperature Profile
C. Precipitable Water
D. Pressure Profile

3.2.1.1.3.3 Multiple Sensor Requirements

3.2.1.1.3.3-1

The GPSOS sensor contractor shall identify any constraints on the relationships between the GPSOS and other co-located satellite sensors that are entailed by the contractor's algorithms for GPSOS primary EDRs. Such constraints might include, for example, relative pointing knowledge, relative pointing accuracy, **and** synchronization. Based on this information and the corresponding information from other sensor development contractors, the government may impose modified or additional requirements on the GPSOS sensor and/or other sensor suites.

3.2.1.1.4 RDR Requirements

Because RDRs are processed into EDRs, RDRs are considered to have met their requirements when they are of an appropriate format, completeness, and quality to be adequately processed into their associated EDRs.

SRDG3.2.1.1.4-1
The GPSOS contractor shall be responsible for generating operational RDRs.

3.2.1.1.5 Earth Location Requirements

SRDG3.2.1.1.5-1
The GPSOS sensor navigational data (Table 3.1.1.1) shall help provide knowledge of all other, co-located payload sensor Lines-of-Sight (LOS). The GPSOS-provided navigational data (Table 3.1.1.1) will allow the Earth location of the other satellite co-located sensors and their associated data in geodetic latitude and longitude to be corrected for altitude within the accuracy specified for each EDR in **the TRD** Appendix D.

3.2.1.1.6 Scientific Algorithms

SRDG3.2.1.1.6-1
The contractor shall provide EDR scientific algorithms.

SRDG3.2.1.1.6-2
The EDR scientific algorithms shall, when used on GPSOS data, provide EDRs that satisfy NPOESS requirements.

SRDG3.2.1.1.6-3
The contractor shall also identify use of any auxiliary data. The government's Operational Algorithm Teams (OATs), may also recommend science algorithms. These teams have contributed to the definition of the sensor requirements of Section 3. The OATs may also provide advisory information on GPSOS functional and calibration requirements.

SRDG3.2.1.1.6-4
The performance of the scientific EDR algorithms delivered by the GPSOS sensor contractor shall meet EDR thresholds and be no worse than the performance of algorithms utilized for current (TBR) operational data products for these EDRs, if such operational products exist.

SRDG3.2.1.1.6-5
The contractor shall identify and quantify any EDR performance degradation resulting from the lack of availability of any database or other ancillary data.

3.2.1.1.7 Scientific Algorithm Convertibility to Operational Code

The government considers the SDR and EDR algorithms adopted, adapted, or developed by the GPSOS contractor to be scientific, rather than operational, algorithms. The GPSOS contractor is not responsible for identifying or developing operational SDR and EDR algorithms for the GPSOS. (Any operational algorithms necessary for the generation of RDRs will ultimately be the responsibility of the GPSOS contractor, and the operational code implementing these algorithms will be part of the required flight software. This statement applies to the post-downselect phase, i.e., Post-PDR, of the GPSOS program.)

SRDG3.2.1.1.7-1
The scientific SDR and EDR algorithms delivered by the GPSOS contractor shall be convertible into operational code that is compatible with a 20 minute maximum processing time at either the DoD Centrals or DoD field terminals for the conversion of all pertinent RDRs into all required EDRs for the site or terminal, including those based wholly or in part on data from other sensor suites. The intent of this requirement is to preclude scientific algorithms that are so computationally intensive that any foreseeable implementation would stress or exceed the time available for delivery of EDRs in an operational environment. The GPSOS sensor contractor is to assume that the GPS Ground net data, i.e., IGS, is made available within the 20 minute maximum processing time as Government Furnished Information (GFI). The GPSOS contractor is to identify to the Government the IGS data input format requirement.

SRDG3.2.1.1.7-2
The contractor shall validate the requirement that scientific algorithms be convertible to operational code subject to the constraint specified in SRDG3.2.1.1.7 is (TBR).

SRDG3.2.1.1.7-3
The availability of any inputs required from databases or other ancillary sources to generate data products shall also be adequate to allow EDRs to be generated at the DoD Centrals and DoD field terminals within the time constraint specified in 3.2.1.1.7-1.

3.2.1.1.8 GPSOS Interface to GPS and GLONASS Satellites

SRDG3.2.1.1.8-1
The GPSOS shall demonstrate compatibility with the GPS (GPS ICD 200) and the GLONASS satellites and satellite constellations to the extent required for the GPSOS to perform its navigation function and to produce its assigned set of Primary and Secondary EDRs.

3.2.1.2 Sensor Calibration , See Section 3.1.1.1

3.2.1.3 Data Access

SRDG3.2.1.3-1
The GPSOS shall provide to the Command and Telemetry (C&T) data bus, per SRDX3.2.4.8.2.1-1, the determination of position and time, per SRDG3.2.1.1-1 and SRDG3.2.1.1-2, respectively.

3.2.1.4 Data Format

SRDG3.2.1.4-1
A single, interchangeable GPSOS sensor data format shall conform to the POES/DMSP/METOP system format and data rate (TBS).

SRDG3.2.1.4-2
For NPOESS satellites, the sensor shall conform to the Consultative Committee for Space Data Systems (CCSDS) packetization per the (TBS) real-time interface specification and the (TBS) stored-data interface specification.

SRDG3.2.1.4-3
If data compression techniques are used in stored data retrieval, the compression shall be lossless.

3.2.1.5 Deleted

SRDG3.2.1.5-1
Deleted.

SRDG3.2.1.5-2
Deleted.

SRDG3.2.1.5-3
Deleted.

SRDG3.2.1.5-4
Deleted.

SRDG3.2.1.5-5
Deleted.

SRDG3.2.1.5-6
Deleted.

3.2.2 SENSOR CAPABILITY RELATIONSHIPS

3.2.2.1 Deleted

SRDG3.2.2.1-1
Deleted.

3.2.2.2 Deleted

SRDG3.2.2.2-1
Deleted.

3.2.3 INTERFACE REQUIREMENTS

The GPSOS interface requirements include the NPOESS spacecraft and other risk-reduction Flight-of-Opportunity spacecraft including, but not necessarily limited to, the DMSP, the POES, and the METOP spacecraft. GPSOS interfaces to the GPS and GLONASS are described in Section 3.2.1.1.8.

SRDG3.2.3-1
The GPSOS shall be compatible with and interface to the NPOESS spacecraft (TBR).

SRDG3.2.3-2
The GPSOS shall be compatible with and interface to selected risk-reduction Flight-of-Opportunity spacecraft (TBR). Potential Flight-of-Opportunity spacecraft for the GPSOS include the DMSP, the POES, and the METOP satellite series.

The system interfaces relevant to the sensors are depicted in Figure 3.2.3 below.

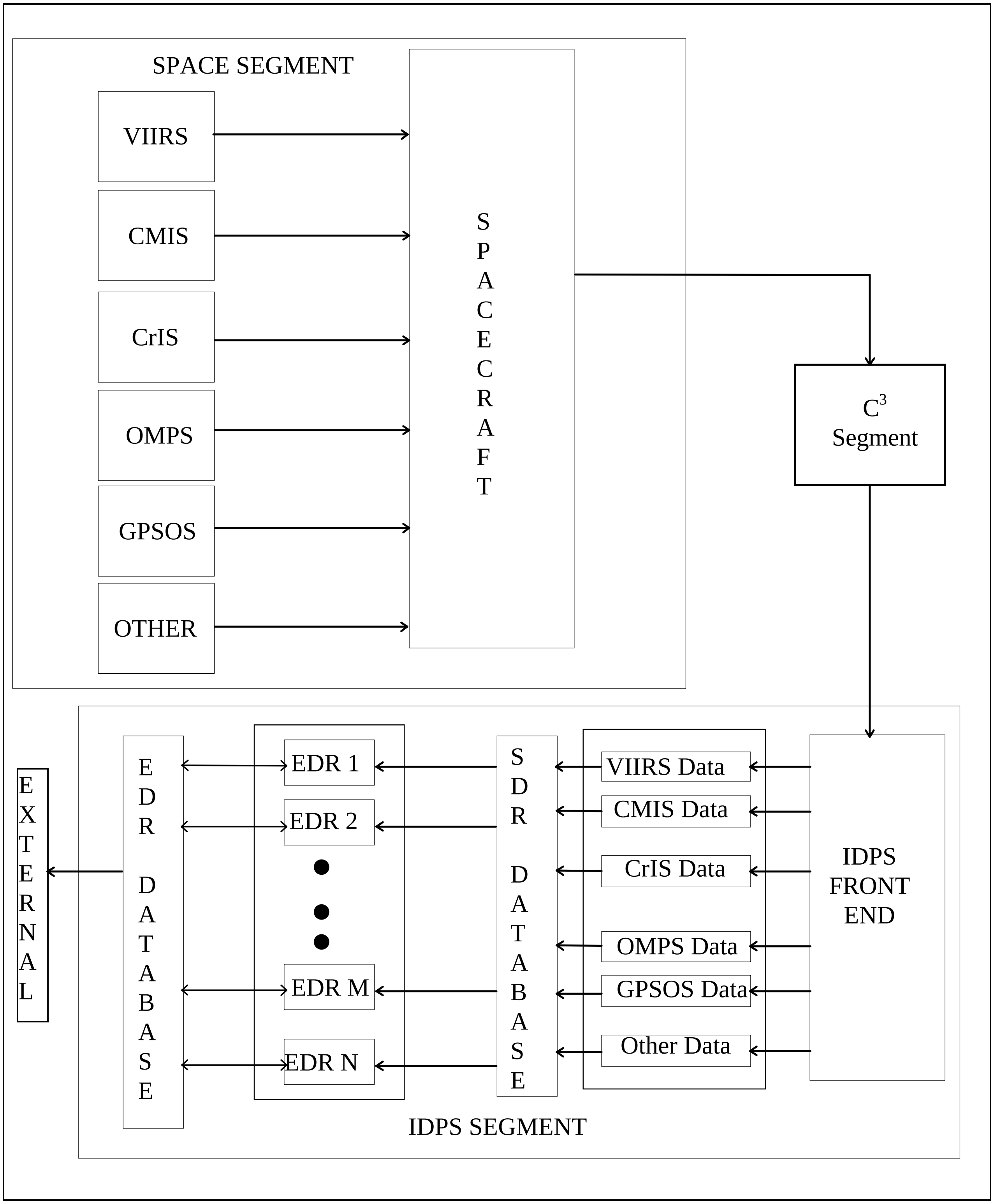

Figure 3.2.3 Partial System Internal Interfaces

3.2.4 PHYSICAL AND INTERFACE CHARACTERISTICS

Weight, power, volume, and data rates described herein are nominal values (with contingency) which were developed during initial studies at the Integrated Program Office. All values are defined as: TBR, indicating that specific allocations are negotiable. It is presently planned that definitive allocations will be defined by the IPO, in consultation with sensor contractors, by the time of the SRR. In the interim, contractors should keep in mind that relaxation from nominal allocations will only be possible if changes are consistent with the requirement to accommodate the full NPOESS payload suite of instruments on a spacecraft which can be placed into a nominal 833 Km orbit by an EELV class launch vehicle.

The following constraints are based on initial allocations from the NPOESS notional baseline. These constraints are expected to be further refined during the initial contract efforts. The following numbers include all margins assigned to the GPSOS sensor.

SRDG3.2.4-1
Mass (kilograms—kg) of the GPSOS sensor shall be less than or equal to 9 kg total: Receiver /Processor: 4 kg (TBR), Oscillator: 2 kg (TBR), Antenna(s): 3 kg (TBR).

SRDG3.2.4-2
Power (watts) of the GPSOS sensor shall be less than: 13 watts (TBR).

SRDG3.2.4-3
The GPSOS sensor shall conform **to** the following size restrictions: Dimensions (cm) of the GPSOS sensor: Receiver/Processor: 26 cm X 24 cm X 13 cm (TBR); Oscillator: 18 cm X 11 cm X 8 cm (TBR); and Antenna(s): 14 X 14 X 2 (TBR). Components mounted internal to the spacecraft bus (TBS).

SRDG3.2.4-4
The GPSOS shall have a nominal data rate of 20 Kbps (Min) to 80 Kbps (Max) to the spacecraft (TBR).

See GPSOSb-Rev1.doc